Verification of Translation

I, Shuji Yoshizaki, do hereby declare that I am familiar with Japanese and English Languages, and the attached document is a faithful English translation of Japanese Patent Application No. 236040 filed on August 13, 2002.

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[Name of the document] Descriptions

[Name of the invention] Lens array sheet

[Claims]

[claim 1] A lens array sheet having a plurality of pyramid-shaped projections or recesses on a surface of its transparent base material film.

[claim 2] The lens array sheet as set forth in claim 1, wherein a bottom surface of the pyramid shape is a rectangular or square shape satisfying a relationship of (length "a" of one side) $\leq$ (length "b" of other side) $\leq$ 10a.

[claim 3] The lens array sheet as set forth in claim 1, wherein a base angle θ of side surfaces of the pyramid shape is 20° to 80°.

[claim 4] The lens array sheet as set forth in claim 1, wherein the transparent base material film is composed of an alicyclic olefin resin as a main component.

[claim 5] The lens array sheet as set forth in claim 1 produced by injection molding using a mold having pyramid-shaped projections or recesses on its surface.

[claim 6] A metal mold comprising pyramid-shaped projections on the surface produced by peeling the mold from the metal layer after forming the metal layer by stacking the metal on the silicon mold surface made by following the steps of;

(1) forming a positive type resist pattern on a silicon wafer formed on its surface with a silicon oxide layer, followed by,

(2) forming a silicon oxide pattern by performing etching on the silicon oxide layer by an etching solution containing hydrofluoric acid by using the resist pattern as a mask, then

(3) removing the resist pattern and performing anisotropic etching on the silicon wafer surface by an alkaline solution to form pyramid-shaped recesses, and

(4) removing the silicon oxide pattern by an etching solution containing hydrofluoric acid.

[claim 7] The metal mold comprising pyramid-shape recesses on the surface produced by peeling the mold from the metal layer after forming the metal layer by stacking the metal on the surface of the metal mold as set forth in claim 6 as the mold.

[claim 8] A light condensing plate comprised of lens array sheet as set forth in claim 1.

[claim 9] An organic electroluminescence element comprised of a transparent electrode layer, an organic electroluminescence material layer and a metal electrode layer stacked on a transparent substrate in this order, wherein said transparent substrate is the lens array sheet as set forth in claim 1.

[Detailed description of the invention]

[0001]

The present invention relates to a lens array sheet suitable to a light condensing plate used for a display device of an organic electroluminescence element and liquid crystal.

[0002]

[Descriptions of related arts]

There are demands for a surface lighting device used for a display device to have many characteristics, such as high luminance, low power consumption and thin shape. When improving one of these characteristics, it is liable that other performance has to be more or less sacrificed and it has been very difficult to improve all performances at a time.

To overcome the plurality of challenges, a sheet (lens array sheet) having a lens array formed with a fine concave and convex pattern, such as a prism shape and a Fresnel lens shape, on a surface of a thermoplastic resin mold, such as a transparent

plastic, has been increasingly used as an optical part in recent years.

For example, a method of easily attaining high luminance by using a lens array sheet as a light condensing plate for a liquid crystal display device and condensing a display light in an approximately normal direction has become widely used. This method uses a light condensing effect of a prism and is capable of attaining high luminance without increasing an electric power and a thickness of the device, while it has a disadvantage that the luminance drastically declines when being out of the light condensing range.

To solve such a disadvantage, the Japanese Unexamined Patent Publication No. 7-261006 proposes to change a refraction index between one surface and the other surface of the prism. Also, the use of a material of the light condensing plate an alicyclic structure containing thermoplastic resin having a norbornene structure has been proposed (Japanese Unexamined Patent Publication No. 2000-75102).

Since an organic electroluminescence material can be used as a thin film, it is an effective material for making a surface lighting device and a display device thinner and lighter, however the light transmittance of a liquid crystal panel is too low to be used as a backlight of a liquid crystal display device, the light condensing efficiency has to be furthermore

improved compared to that of a conventional backlight using a cold-cathode tube, etc.

However, when using a prism lens having a line shaped surface, which has been conventionally used as a light condensing plate of a liquid crystal substrate, as a light condensing plate of an organic electroluminescence element, there is a disadvantage that the viewing angle differed depending on the viewing direction.

[0003]

[Objectives to be solved by the invention]

Under such observation, the present inventors confirmed that a line shaped prism lens converges a light only in one direction and that the disadvantages explained above arise. As a result that they have been committed themselves to study for attaining an improvement in light convergence, they found that a lens array sheet having pyramid-shaped projections and recesses is capable of condensing even a light from an organic electroluminescence element most effectively comparing with ones having projections and recesses in a three-sided pyramid, six-sided pyramid, eight-sided pyramid or conical shape, so that the present invention has completed.

[0004]

[Means of solving the objectives]

There is provided a lens array sheet having a plurality

of pyramid-shaped projections or recesses on the one of the surface of transparent base material film wherein comprises steps of;

(1) forming a positive type resist pattern on a silicon wafer formed on its surface with an silicon oxide layer followed by,

(2) forming a silicon oxide pattern by etching the silicon oxide layer by an etching solution containing hydrofluoric acid by using the resist pattern as a mask, then

(3) removing the resist pattern and performing anisotropic etching on the silicon wafer surface by an alkaline solution to form pyramid-shaped recesses, and

(4) removing the silicon oxide pattern by an etching solution containing hydrofluoric acid. After forming a metal layer by staking a metal on the surface of a silicon mold surface following the above steps, the metal mold having pyramid-shaped projections is provided on a surface made by peeling the mold and the metal layer;

furthermore, the metal mold having pyramid-shaped projections were using as the mold, and after forming the metal layer by stacking the metal to the surface thereof, and a metal mold having pyramid-shaped recesses were provided on the surface made by peeling said mold and the metal layer are provided and; an organic electroluminescence element comprised of a transparent electrode layer, an organic electroluminescence

layer, and a metal layer is stacked in this order on the transparent base material film, wherein the organic electroluminescence material layer as the lens array sheet of the present invention is provided on said transparent base material.

[0005]

[The preferred embodiments of the invention]

The lens array sheet according to the present invention forms plurality of pyramid-shpaed projections or recesses on one side of the transparent base material film.

The transparent base material film is a film shaped mold of a transparent resin material.

As specific examples of the transparent resin material, polyethylene, polypropylene, polymethylpentene and other linear polyolefin resins; polystyrene and other aromatic vinyl based resins; a norbornene based polymer, a vinyl alicyclic hydrocarbon polymer, a monocyclic olefin based polymer, a cyclic diolefin based polymer and other alicyclic olefin resins; polycarbonate, polyethylene phthalate, polybutylene phthalate, liquid crystal polyester and other polyester based resins; polymethyl methacrylate and other acrylic resins; an acrylonitrile styrene resin, an acrylonitrile styrene butadiene resin and other acrylonitrile based resins; polysulfone, polyether sulfone, polyphenylene sulfide,

polyphenylene ether and other polyether based resins; and polyether ether ketone and other ketone based resins; may be mentioned. Among them, a linear polyolefin resin, an alicyclic olefin resin and polyether based resin, etc. are preferable because they easily bring cross-linking reaction by irradiation of an active energy beam and solubility in specific solvents easily changes. Furthermore, an alicyclic olefin resin is the most preferable because of less absorption of visible light and a low water-absorbing property.

[0006]

As specific examples of an alicyclic olefin resin, a ring-opened polymer of a norbornene based monomer and the hydrogenated product, a ring-opened polymer of other monomer capable of copolymerizing with a norbornene based monomer and the hydrogenated product, an addition polymer of a norbornene based monomer and the hydrogenated product, an additional copolymer with other monomer capable of copolymerizing with a norbornene based monomer and the hydrogenated product and other norbornene based polymers; polyvinylcycloalkane, polyvinylcycloalkene, hydrogenated product of an aromatic vinyl polymer and other vinyl alicyclic hydrocarbon polymer; polycyclopentene, polycyclohexene and other monocyclic olefin based polymers; polycyclohexadiene and other cyclic diolefin based polymers; etc. may be mentioned. Among them, a norbornene

based polymer and a vinyl alicyclic hydrocarbon polymer are the most preferable. Also, a vinyl alicyclic hydrocarbon polymer may be a copolymer with other monomer (for example, butadiene, isoprene and other vinyl based monomers, etc.) capable of copolymerizing with vinylcycloalkane, vinylcycloalkene and an aromatic vinyl based monomer, etc., and the polymer form may be either of a block polymer and a random polymer.

[0007]

Although a method of forming pyramid-shaped projections or recesses on a surface of the transparent base material film is not particularly limited, for example, (1) a method of setting a mold formed with pyramid-shaped projections or recesses to perform injection molding, compression molding or heat-melt molding, such as blow molding, (2) a method of using a die formed with pyramid-shaped projections or recesses to perform melt extrusion molding, (3) a so-called 2P method for applying an ultraviolet ray curing resin on a molding surface formed with pyramid-shaped projections or recesses, then, curing the resin by irradiating an ultraviolet ray to transfer a pattern, may be mentioned. Among them, (1) a method of transferring a pattern by using the method setting a mold formed with pyramid-shaped projections or recesses to perform injection molding, compression molding or heat-melt molding, such as blow molding is preferable.

[0008]

Although a method of producing a mold is not particularly limited, for example, to produce a mold having pyramid-shaped "projections" on its surface, a method of forming a metal layer by stacking a metal by a soldering method or a sputtering method, etc. on a substrate formed with a pyramid-shaped concave pattern, then, peeling the metal layer from the substrate may be mentioned.

To obtain a mold having pyramid-shaped "recesses" on its surface, a method of using a mold having pyramid-shaped projections obtained as above and performing mold release processing for bringing this surface into contact with potassium bichromate or other oxidizing agent, etc. in accordance with need, then, forming a metal layer by the same method as above by stacking metal, and peeling the metal layer from the mold may be mentioned.

[0009]

A method of obtaining a substrate formed with the pattern is not particularly limited, and a method of using a property that a silicon single crystal substrate is anisotropically etched by an alkaline solution (etching solution) may be mentioned as a preferable example because a fine pattern is easily obtained. Specifically, this method is by (1) stacking an oxidized silicon film and a photo resist film on a silicon

substrate in this order, then, forming a pattern on the photoresist film, (2) performing etching on the oxidized silicon layer by an etching solution containing hydrofluoric acid by using the resist pattern as a mask to form a silicon oxide pattern, (3) furthermore, performing anisotropic etching on the silicon substrate by a sodium hydroxide solution or other alkaline etching solution to form pyramid-shaped recesses on the silicon substrate (at this time, the resist pattern can be also removed at a time for it is soluble in the alkaline etching solution), and (4) bringing the finally left silicon oxide pattern into contact with an etching solution containing hydrofluoric acid to remove the silicon oxide pattern, projection or recesses (pattern) is formed on the surface of the silicon substrate.

When forming pyramid-shaped projections or recesses on a surface of a transparent base material film by using a mold produced by the above explained method, a width of a resist pattern to be a mask becomes a width of a lens array sheet of the present invention. The narrower the width is, the more preferable. It is preferably 50% or less, more preferably 20% or less, further preferably 10% or less and particularly preferably 5% or less with respect to a length "a" of one side of the bottom surface of the pyramid shape.

[0010]

The pyramid-shaped projections or recesses of the lens array sheet may have a pyramid shape having different base angles of side surfaces or a right pyramid shape wherein all of the bottom angles are the same. Also, it may be a pyramid shape wherein an apex angle is cut off. Specifically, the forms shown in Fig.1 are the examples.

Also, in terms of improving front luminance by improving the light condensing property, it is preferable that the bottom surface of the pyramid shape is a rectangular or square shape wherein preferably rectangular or square shape having (length "a" of one side) ≤ (length "b" of other side) ≤ 10a, more preferably rectangular or square shape having (length "a" of one side) ≤ (length "b" of other side) ≤ 5a, further preferably rectangular or square shape having (length "a" of one side) ≤ (length "b" of other side) ≤ 2a, particularly rectangular or square shape having (length "a" of one side) ≤ (length "b" of other side) ≤ 1.5a is preferred.

The length of one side of the bottom surface "a" of the present invention is not particularly limited; however it is normally 0.1 μm to 500 μm, preferably 0.1 μm to 100 μm, and particularly in the case of obtaining an organic electroluminescence element by using a lens array sheet of the present invention as a light condensing plate and using it as a backlight of a liquid crystal display device, it is preferably

0.1 μm to 20 μm, so that the liquid crystal is capable of preventing interference by an outside light (so-called moiré).

Also, the base angle of side surface of the pyramid shape is preferably 20° to 80°, particularly preferably 30° to 75°.

A height "c" of the pyramid shape (a length from the bottom surface to the apex angle) is not particularly limited and is preferably $0.2a \leq c \leq 2a$, more preferably $0.5a \leq c \leq 1.5a$ with respect to the length "a" of one side of the bottom surface.

[0011]

It is sufficient when a large number of the projections and recesses as above are arranged on a surface of a lens array sheet, and directions of the respective projections and recesses may be a regular lattice shape as shown in Fig. 2, a hound's-tooth check shape (Fig.2(b)), or a random shape(Fig.2(c)). A regular lattice shape or hound's-tooth check shape is preferable for obtaining higher luminance.

Also, a shape of the respective projections or recesses arranged on the surface of the lens array sheet may be all same or independent shapes from one another.

[0012]

A light condensing plate of the present invention is made by the above lens array sheet and an organic electroluminescence element of the present invention is obtained by stacking a transparent electrode layer, such as indium tin oxide (ITO),

an organic electroluminescence material layer including an organic luminous element, and a metal electrode layer in this order on the lens array sheet as a transparent substrate. In the organic electroluminescence element, the lens array sheet functions as a light condensing plate.

The organic electroluminescence element can be used as a backlight of a liquid crystal display device, etc.

[0013]

The preferred embodiments of the present invention will be explained in the following.

After applying a positive type photoresist composition (product name: ZPP1700PG) made by ZEON Corporation by spin-coating on a substrate obtained by forming a film of SiO_2 to 300Å on a silicon, the result was prebaked at 100°C to obtain a resist film of 1.5 μm on the substrate.

The obtained resist film was subjected to exposure of 50 mJ/cm^2 by an exposure apparatus "PLA501F" made by Canon Inc. via a mask, development processing was performed by a 2.38% tetramethyl ammonium hydroxide solution for 60 seconds, and then, rinse processing by ultrapure water was performed for 30 seconds. The substrate was dried by spin processing and prebaking processing at 120°C was finally performed to obtain a resist pattern on the substrate.

The thus obtained substrate was dipped in a hydrofluoric

acid buffer solution (mixture of 3.6% hydrofluoric water and 18% hydrofluoric ammonium water by 1:1 (in volume) at 20°C (It will be the same below) for five minutes to etch SiO_2, rinsing process for immersing the etched substrate in pure water for 60 seconds was performed, then, the substrate was dried by spin processing.

The substrate, wherein the oxide silicon film was etched, was immersed in a 30% sodium hydroxide solution for 30 minutes at 80°C, immersed in pure water for 60 seconds, then, dried by blowing a dry air, so that pyramid-shaped concave recesses were formed on the silicon substrate.

To remove an excessive oxide silicon film remaining on the silicon substrate formed with the recesses, the substrate was dipped in a hydrofluoric acid buffer solution for 5 minutes, then, immersed in pure water for 60 seconds, and dried by blowing a dry air, so that a silicon substrate having pyramid-shaped recesses was produced.

[0014]

After adhering the obtained silicon substrate on a fixture and forming a nickel film of about 500Å by vacuum evaporation on the surface, nickel metal was grown by performing electrolytic soldering in an electrolytic solution containing nickel sulfamate as its main component. The obtained nickel block was peeled from the silicon substrate to produce a metal

mold. This mold was set in an injection molding apparatus to obtain a lens array sheet (the outside dimension is 40 mm × 40 mm) having a thickness of about 1 mm by injection molding (resin melt temperature of 285°C, mold temperature of 130°C, and resin filling time of about 0.2 second) using a cycloolefin polymer (ZNR1430R made by ZEON Corporation).

The obtained lens array sheet was formed on its surface with pyramid-shaped "recesses" having a bottom surface of 20 μm × 20 μm, a base angle of side surfaces of approximately 55° and a height of 14 μm in a hound's-tooth check shape.

[0015]

ITO having a thickness of 300Å was evaporated on the thus obtained lens array sheet, the result was washed with steam of IPA, set in an organic electroluminescence element producing apparatus, and subjected to plasma processing at 100W under an atmosphere of oxygen/argon = 50/50 for 5 minutes.

After that, the result was transferred to an organic evaporation chamber, and N,N-di(1-naphthyl)-N,N'-diphenyl-1,1'-diphenyl-1,4-imine (NPD) as a hole transport material and 8-hydroxy quinoline aluminum (Alq3) as an electron transport material were put in two melting pots wound by coil. Then, inside the chamber was depressurized to 10^{-6} Pa and a current of 20A was applied to the coil holding NPD to perform evaporation until the film

thickness becomes 400Å, then, evaporation was performed under the same condition until a film thickness of Alq3 becomes 600Å, so that an organic electroluminescence material layer was stacked.

After that, the substrate was moved to a metal evaporation chamber while keeping in the system in a vacuum state, and lithium fluoride loaded on a metal board was heated, so that the lithium fluoride was evaporated to be 5Å on the organic layer. Then, aluminum was loaded on another metal board to evaporate it to be a thickness of 1000Å by the same operation, so that a stacked body, wherein an ITO layer, an organic electroluminescence material layer and a metal electrode layer were stacked, was obtained on the lens array sheet.

[0016]

The thus obtained stacked body was attached with a stainless sealing tube applied with an ultraviolet ray curing adhesion in a globe box in a dry nitrogen, and an ultraviolet ray was irradiated to adhere the sealing tube, consequently, an organic electroluminescence element was obtained.

Measurement of luminance was made on the obtained element by a luminance measurement device (BM-8 made by TOPCON CORPORATION) in a vertical state with respect to the substrate surface of which result was 2165 cd/cm^2.

On the other hand, other than using a film of a cycloolefin

polymer (ZNR1430R made by ZEON Corporation) having a thickness of 1 mm and not formed with concaves and convexes instead of the lens array sheet, an organic electroluminescence element was produced in the same method, and the luminance was measured under the same condition of which result was 1250 cd/cm^2. That is, by using the lens array sheet as a light condensing plate, luminance of the organic electroluminescence element was improved by about 1.5 times.

[0017]

Also, as obtained in the above, the metal mold (concave metal mold) having concave pattern wherein the pyramid-shaped recessions are formed in hound's-tooth check shape is immersed in a potassium bichromate solution (0.1 wt%) for 30 seconds and mold releasing processing was performed by oxidizing the mold surface, then, a nickel layer (metal layer) was stacked under the same condition as that in the above, followed by peeling the metal mold from concave metal mold so that a mold (convex mold) formed with pyramid-shaped projections having a base angle of side surfaces of approximately 55° and a height of 14 μm in a hound's-tooth check shape was obtained. When the lens array sheet was formed as same as the above using this convex metal mold, and the organic electroluminescence element was formed using said lens array sheet, the luminance was improved by 1.7 times compared to that of when using 1mm thick film of

cycloolefin polymer without the formation of the concave-convex (ZNR1430R made by ZEON Corporation).

Therefore, when using a lens array sheet formed with a plurality of projections or recesses on one surface of a transparent base material film as a light condensing plate, luminance of an organic electroluminescence element was found to improve. Particularly, when using the lens array sheet formed with the pyramid-shaped projections on one surface of the transparent base material as the light condensing plate, higher luminance can be obtained.

[0018]

[The effect of the present invention]

A lens array sheet of the present invention exhibits remarkable efficiency in improving luminance as a light condensing plate of an organic electroluminescence element.

The lens array sheet of the present invention can be used as an optical part, such as an information recording medium, optical lens, optical filter, light guide plate for a liquid crystal display device and optical sheet, in addition to being used as a light condensing plate of an organic electroluminescence element.

[Brief description of the drawings]

[Fig.1] Fig.1 illustrates the examples of the pyramid shape. The upper figures are the view from the top and the lower figures

are the corresponding view from the side.

[Fig.2] Fig.2 illustrates the top view of the pyramid-shpaed projections or recesses formed on the lens array sheet.

Note that, (1) and (3) are the sectional view of pyramid-shpaed projections or recesses formed in regular lattice shape. (2) and (4) are the sectional view of the pyramid-shaped projections and recessions formed in hound's-tooth check shape, and the broken lines indicates the pyramid-shpaed projections or recesses of the following line.

[Fig.3] Fig.3 illustrates the sectional view of the examples of the pyramid-shaped projections and recessions formed on the lens array sheet.

[Descriptions of the notes]

a: Length of one side formed on the base of the pyramid shape.

b: Length of other side formed on the base of the pyramid shape.

c: Height of the pyramid shape.

θ: Angle of the side surface of the pyramid shape.

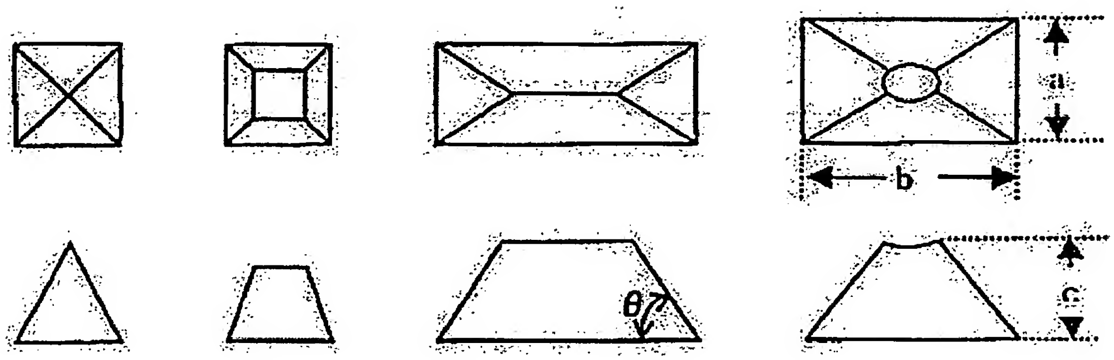
1: Pyramid-shpaed projections or recesses.

2: Lens array sheet

3: The width between the pyramid-shpaed projections or recesses.

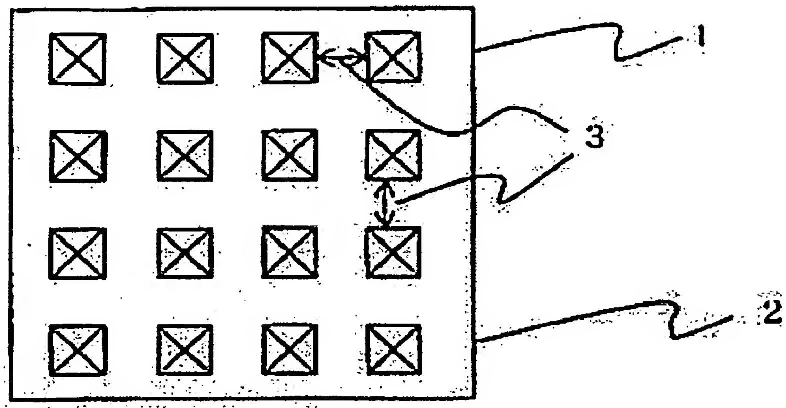
[Name of the document] Figures

[Fig.1]

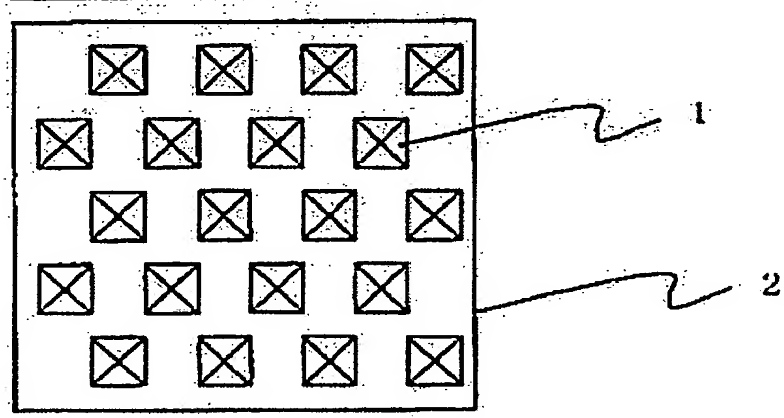


[Fig.2]

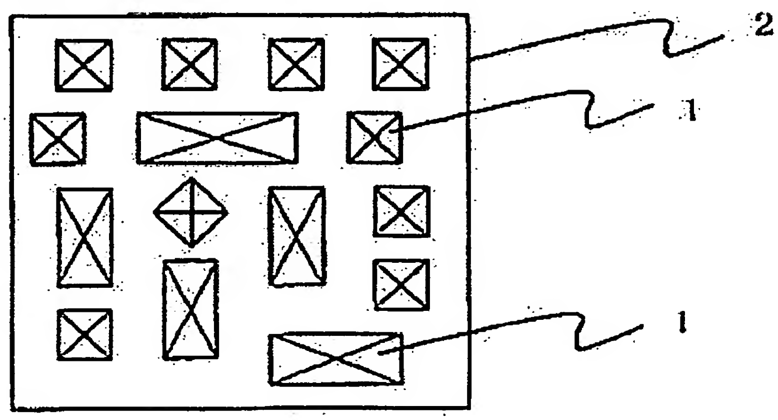
(a)



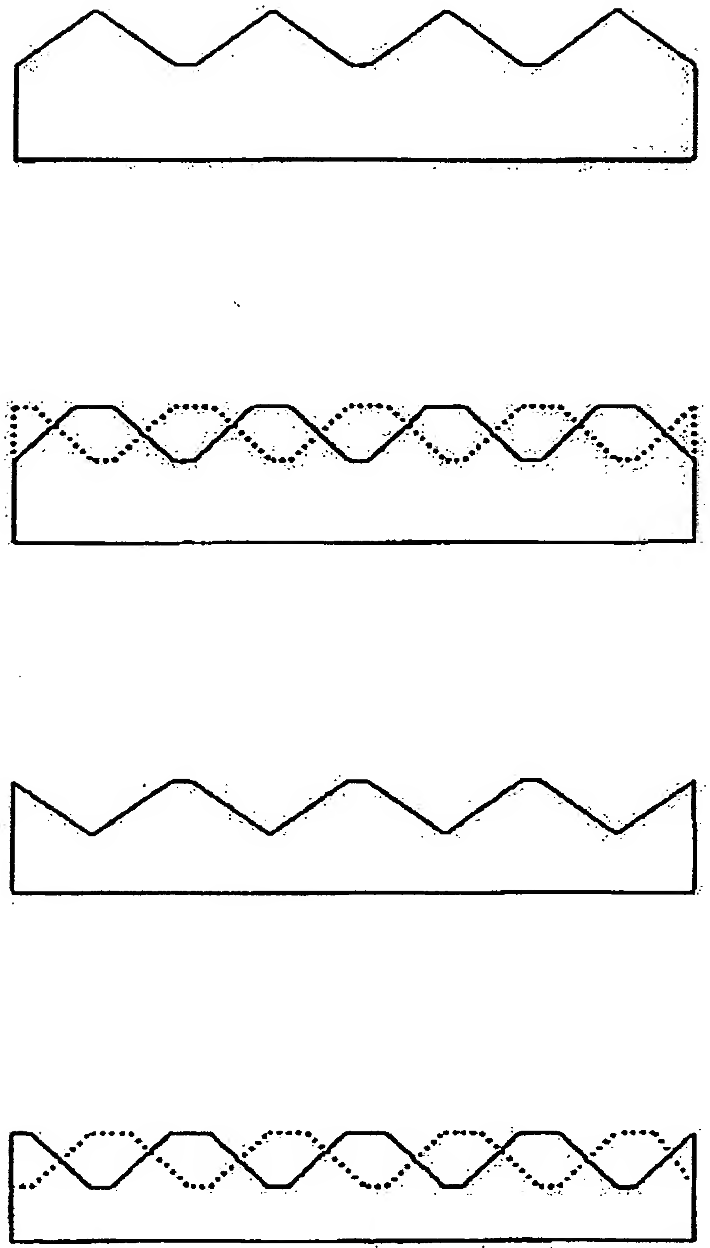
(b)



(c)



[Fig.3]



(1)

(2)

(3)

(4)

[Name of the document] Abstract

[Abstract]

[Objective] To provide a lens array sheet particularly suitable for the light condensing plate of organic electroluminescence element.

[Means of solving] The lens array sheet formed with plurality of pyramid-shpaed projections or recesses formed on one side surface of the transparent base material film. This is used as the light condensing plate, and thereon, transparent electrode layer, organic electroluminescence material layer, and metal electrode layer are stacked in this order to form organic electroluminescence element.

[Selected figure] Fig.1